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REAL OPTIONS AND DISCOUNTED CASH FLOW ANALYSIS TO ASSESS STRATEGIC INVESTMENT PROJECTS

Agnė PIVORIENĖ

Kaunas University of Technology, Lithuania
Corresponding author e-mail: agne.pivoriene@ktu.lt

Abstract. In today's uncertain and highly competitive business environment, the difficulty to make strategic investment decisions is growing. The dominant discounted cash flow analysis requires the assumption of perfect certainty of project cash flows. However, under uncertainty traditional DCF approach falls short of providing adequate strategic decision support, and this situation demands new methods for investment evaluation. Real options approach (ROA) has shown the potential for valuation of strategic corporate investment decisions and managerial flexibility in situations of high uncertainty. Under ROA, projects are viewed as real options that can be valued using financial option pricing techniques. This framework allows their owner to keep investment options open and to benefit from the upside potential of an opportunity while controlling the downside risk. The main aim of this research is to investigate the feasibility of real options approach and traditional DCF analysis for assessment of strategic investment projects under environmental uncertainty.

***Keywords**: Discounted cash flow analysis, real options, strategic investment projects, uncertainty.*

INTRODUCTION

Strategic investment projects condition future opportunities of a company and have substantial impact on its long-term survival, corporate growth, competitive advantages, profitability, shareholder value creation and success. Therefore, for the purpose of making effective strategic capital investment decisions that increase business subject's value, reliable investment assessment methodologies are required.

The analysis of academic literature shows that the appropriateness of an investment evaluation tool is determined by the characteristics of an investment project and the level of environmental uncertainty. Yet, regardless of the uncertainties present in a decision environment, traditional DCF model for strategic investment project evaluation is a commonly used methodology to assess whether to begin an investment or not.

When uncertainty is high, strategic investment projects contravene the assumptions of DCF and this type of analysis provides inadequate investment decision support. Therefore, there is a growing interest in ROA to guide strategic investment decisions in dynamic environments.

RO theory is the application of financial options pricing theory for the assessment of real assets.

By evaluating and managing strategic investment projects under uncertainty, this approach encourages proactive investment management and, if used properly and recognized in real life managerial surroundings, can greatly improve strategic investment decision making.

This research aims to investigate the feasibility of real options approach and traditional DCF analysis in order to assess strategic investment projects under environmental uncertainty.

The following research methodology was used: after systematization and generalization of the scientific literature for the analysis of the peculiarities of strategic investment project valuation techniques, specifically DCF analysis and ROA, the traditional DCF model was calculated to analyse the value of strategic investment project without options and the RO valuation approach was applied for the option to expand.

1. STRATEGIC INVESTMENT PROJECT VALUATION: DISCOUNTED CASH FLOW ANALYSIS AND REAL OPTIONS APPROACH

Over the past four decades, plenty of capital budgeting surveys have been performed to collate corporate finance theory with the strategic investment evaluation practice of financial managers. According to their results (Ryan & Ryan, 2002; Block, 2007; Ghahremani et al., 2012; Andor et al., 2015), the most commonly employed method to evaluate a strategic investment project is the DCF model. It is based on a fundamental principle of finance – time value of money.

In traditional DCF analysis, the net present value (NPV) is the value of a project to an investor.

NPV, the sum of the present values of annual cash flows, is calculated as follows (Trigeorgis, 2000):

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - I, \tag{1}$$

where C_t is the expected net cash inflow in year t, I is the single initial investment outlay, r is the discount rate (opportunity cost of the company undertaking the investment), and T is the number of years of the project life.

Generally, if the NPV is positive, the investment project is viewed as economically attractive.

The research of academic literature disclosed that DCF analysis is relatively easy to implement, widely taught, widely accepted and has many advantages over alternative investment evaluation methodologies (Thomas, 2001; Mun, 2006; Regan et al., 2015; Locatelli et al., 2016) in that it: a) is a definite, consistent decision making criterion for all investment projects; b) grants the same results, despite of risk preference of investors (these results are economically rational, precise and quantitative); c) is less vulnerable to accounting formalities; d) factors in both risk and the time value of money. Furthermore, this model supports effective investment decision making, if the strategic investment decision fulfils the assumptions of the analysis, i.e. under stable environmental conditions when uncertainty is low enough for managers to make reasonably precise forecasts, when projects are uncomplicated and investments maintain the stock company's existing capabilities.

However, under uncertainty strategic investment projects violate a large part of DCF assumptions, causing DCF analysis to be of limited value or misleading.

The issue of the main limitations associated with DCF analysis has already been addressed in finance research (Adler, 2000; Dessureault & Scoble, 2000; Park & Herath, 2000; Yeo & Qiu, 2003; Pless et al., 2016; Schachter & Mancarella, 2016) and is summarized as follows:

- It focuses on tactical investment decision making rather than long-term strategic goals and places short-term goals before long-term profitability. Whereas many strategic investment projects take a long period of time to become fully operational;
- It is difficult to decide upon the correct discount rate. The higher the uncertainty implicated by the project, the higher the discount rate, reflecting a higher risk premium, is used, and the benefits associated with later years' cash flows are greatly diminished;
- It disregards the qualitative benefits that frequently characterize strategic investment projects and the criticality of some investments to the survival of a company;
- It ignores future opportunities and views investment decisions as now or never type decisions. Thereby, the flexibility to modify decisions as new information appears is defied. DCF methodology assumes that regardless the high uncertainty a strategic project will be launched now and continuously operated until the end of its expected life.

Supporters of ROA (for example, Amram & Kulatilaka, 1999; Luehrman, 1998; Trigeorgis, 2000; Topal, 2008; Schober & Gebauer, 2011; Martin-Barrera et al., 2016; Pless et al., 2016) state that the weaknesses of DCF model discussed above can be corrected when using real options analysis.

The real options theory is derived on the basis of the work of Black & Scholes (1973) and Merton (1973) in pricing financial options. A financial option is the right but not the obligation to trade products at a specific time for a predetermined price (Damodaran, 1998).

The Black-Scholes formulas for the prices at time zero of a European call option on a non-dividend-paying stock and a European put option on a non-dividend-paying stock are (Hull, 2000):

$$c = SN(d_1) - X\, e^{-rT} N(d_2) \tag{2}$$

and

$$p = X\, e^{-rT} N(-d_2) - SN(-d_1), \tag{3}$$

where

$$d_1 = \frac{\ln(S / X) + (r + \sigma^2 / 2)T}{\sigma\sqrt{T}} \qquad (4)$$

$$d_2 = d_1 - \sigma\sqrt{T} \qquad (5)$$

and *N(x)* is the cumulative probability distribution function for a variable that is normally distributed, *S* is the current value of the underlying asset, *X* is the strike price, σ is the stock price volatility, *T* is the time to the maturity of the option, and *r* is the continuously compounded risk-free rate.

Continuously compounded risk-free rate is calculated as

$$r = \ln(1 + r_f), \qquad (6)$$

where r_f is the annual risk-free rate of return.

Real options extend this financial management theory to non-financial asset assessments. Consequently, RO can be described as the right but not the obligation to make the strategic investment decision that concerns real assets, i.e. RO theory accepts the managers' ability to change strategic investment project with the purpose of profit maximization and risk minimization under uncertainty.

The ability to make decisions in reaction to risk skews the distribution of possible outcomes towards the upside, increasing the overall value of the project (Pless et al., 2016). That is, ROA allows for a better treatment of volatility compared to DCF as the uncertainty and its purports are not underestimated.

When Black-Scholes equation is used, five parameters are required for the calculation of the financial option value. Linking RO metrics to the Black-Scholes model, for real options it can be observed, that the parameters involve the present value of cash flows from the project, the value of new investment required, the time value of money, the length of time until decision must be made and the volatility of project returns.

Table 1 shows the analogy between the financial and real options.

Table 1. Analogy of a Financial Option relative to Project Characteristics

Financial option	**Real option**
Value of underlying asset	Present value of cash flows from the project
Exercise price	Value of new investment required
Time to expiration	Length of time until decision must be made
Risk-free rate of return	Time value of money
Volatility of stock returns	Volatility of project returns

Source: Compiled by the author, according to Damodaran, 1998; Luehrman, 1998; Pless et al., 2016.

The first four variables in the Black-Scholes model are the same as needful to calculate the NPV. That is, both DCF and ROA depend on the present value calculations of annual cash flows. In the opinion of Eschenbach et al. (2007) and Schachter & Mancarella (2016), volatility is the only added variable, although it is the most complex and the most difficult to determine of the input parameters.

Table 2 presents a detailed comparison of DCF analysis and ROA, applying the criteria that are important for strategic investment project assessment methodologies.

Table 2. Comparison of DCF Analysis and Real Options Approach

	DCF analysis	**ROA**
Uncertainty	Low	High
Mental model	Risk reduction	Opportunity exploration
Managerial flexibility	No flexibility. Static role of management	Flexible. Dynamic role of management
Theoretical assumptions	Restrictive	Robust
Complexity of investment	Simple	Complex
Time value of money	Uses weighted average cost of capital	Uses risk-free rate
Complexity of method	Simple	Complex
Familiarity of decision maker	High	Low
Objective	Shareholder value creation	

Source: Compiled by the author, according to Slater et al., 1998; Trigeorgis, 2000; Topal, 2008; Wang & Halal, 2010; Ghahremani et al., 2012; Pivorienė, 2015; Schachter & Mancarella, 2016.

Despite the existing contrasts between DCF analysis and ROA, DCF and ROA are complementary decision making tools. Many researchers (for example, Damodaran, 1998; Luehrman, 1998; Trigeorgis, 2000; Miller & Park, 2002) suggested the integration of ROA and DCF analysis (i.e. NPV) for project valuation. Trigeorgis (2000) even quantified this approach as follows:

$$\begin{aligned} &Expanded\,(Strategic)\;NPV = \\ &= Static\,(Passive)\;\; NPV\; of\;\; expected\;\; cash\;\; flows + \\ &+ Value\, of\;\; options\;\; from\, active\; management \end{aligned} \tag{7}$$

Some of the real options can occur naturally, while others may be planned and built in at some additional expense (Pivorienė, 2015). The different RO proposed at the time in academic literature (Damodaran, 1998; Amram & Kulatilaka, 1999; Trigeorgis, 2000; Yeo & Qiu, 2003; Martinez Cesena et al., 2013; Martin-Barrera et al., 2016) can be classified as growth (expansion) options, staging options, deferment (learning) options, exit (abandonment or divestment) options and multiple interacting options.

Yet, not all strategic investment decisions are options. According to Krychowski & Quelin (2010) and Chittenden & Derregia (2015), uncertainty, flexibility, irreversibility and information revelation are the main conditions that investment decision has to meet to be suitable for ROA. Thus, the higher the level of uncertainty, the more the ROA impacts strategic investment decisions. Flexibility is the ability of a company to respond appropriately and successively adapt to environmental change. If there is no flexibility, RO generates the same results as DCF analysis. Thus, the least value of ROA is equal to the optimal DCF (Martin-Barrera et al., 2016). Whereas, the information revelation is the possibility to reduce uncertainty during the length of time until decision must be made either by observation or by information acquisition.

Besides, RO strategies differ from their conventional tallies by their mental model and reaction to uncertainty. The change of viewpoint from "reduce risk and minimize investment" to "explore opportunities and maximize learning" determines the usefulness of RO as strategic model. Therefore, the greatest benefit of real options is the way of thinking and this approach is an effective strategic decision making framework for companies to behave flexibly under uncertain environments.

2. A CASE STUDY: OPTION TO EXPAND

Lithuanian company "SE" performs in the renewable energy sector which is highly uncertain. This company is planning to implement the investment and modernization program. The strategic investment to photovoltaic module production line, using innovative technology, is divided into two investment phases. The company, using this advanced technology, will be able to produce not only standard photovoltaic modules but also unframed, glass-back sheet, glass-glass type modules, designed in different colours and with different size parameters. These photovoltaic modules will be supplied to European and Asian clients – state-owned energy companies and private businesses.

Phase 1 includes the investment amount of 4.4 million EUR. This phase will give JSC "SE" an opportunity to modernize processes in main departments and to produce and introduce to the market a new product – monocrystalline and polycrystalline photovoltaic modules.

Phase 2 is the continuation of Phase 1. The investment in the amount of 12.44 million EUR is planned after three years. Phase 2 targets to expand the production of the new product, retain and consolidate position in the existing markets, enter into new markets and complement the existing portfolio of products. The complex investment program is supposed to be financed by company's own funds and EU structural assistance.

The detailed description of the two-phased strategic investment program is showed in Table 3.

Table 3. Cash Flows of the Investment Program (millions of EUR)

Year	2017	2018	2019	2020	2021	2022	2023	2024
Cash flows of Phase 1								
Expected cash flow	0.0	0.54	0.55	0.57	0.59	0.62	0.65	0.68
Perpetuity value (with 5 % growth per year)								7.32
Investment	−4.40							

Cash flows of Phase 2								
Expected cash flow				0.0	1.03	1.08	1.21	1.28
Perpetuity value (with 5 % growth per year)								13.72
Investment				-12.44				
Expected cash flows of the Investment Program	**−4.40**	**0.54**	**0.55**	**-11.87**	**1.62**	**1.70**	**1.86**	**1.96**
Perpetuity value (with 5 % growth per year)								**21.04**
Discount factor (Opportunity cost of capital 14.8 %)	1.000	0.871	0.759	0.661	0.576	0.502	0.437	0.381
Expected discounted cash flows of the Investment Program	**−4.40**	**0.47**	**0.42**	**−7.85**	**0.93**	**0.85**	**0.81**	**8.76**

At first the evaluation of the investment program includes the calculation of the conventional NPV, i.e. the sum of all expected discounted cash flows during the 7 years of life of the investment project less the initial investment outlay in year 2017.

The result of this project evaluation analysis is negative (–0.01 million EUR) and indicates that the two-phased investment program is not acceptable for the investors and will not increase the company's net worth. However, the proposed investment program has substantial option value as the initial investment of 4.4 million EUR grants the right to expand (or not) after three years. This factor is important as the outlays in the third year are three times larger than the initial investment. Analysis of the expected cash flows can assist to recognize the option in this case.

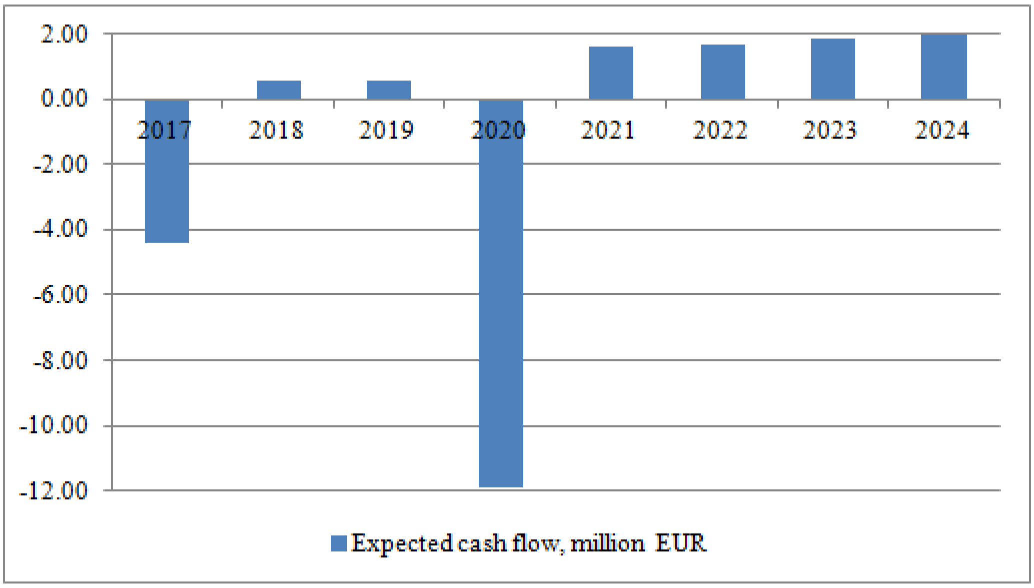

Fig. 1. Expected cash flows of the strategic investment program (Source: Table 3).

Figure 1 shows that the prospective cash flows are uneven, i.e. two negative figures are considerably larger than the other six. The large sum in year three is discretionary. So the company can decide to invest or not, depending on the situation after three years.

The proposed investment program is an option to expand. This is a call option with three years to expiration. The initial investment is strategic, as it creates further growth opportunity, and traditional discounted cash flow analysis values the project wrongly.

Viewing the strategic investment program in this way, it can be evaluated as follows:

$$\begin{gathered} Value\ of\ the\ entire\ proposal = \\ = NPV(Phase1) + Call\ option\ value(Phase2) \end{gathered} \tag{8}$$

NPV of Phase 1 is calculated in Table 4.

Table 4. Net Present Value of Phase 1 (millions of EUR)

Year	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
Expected cash flow	0.0	0.54	0.55	0.57	0.59	0.62	0.65	0.68
Perpetuity value (with 5 % growth per year)								7.32
Investment	−4.40							
Discount factor (14.8 %)	1.000	0.871	0.759	0.661	0.576	0.502	0.437	0.381
Expected discounted cash flows of Phase 1	**−4.40**	**0.47**	**0.42**	**0.38**	**0.34**	**0.31**	**0.28**	**3.05**
NPV	**0.85**							

The Black-Scholes model is used with the purpose to calculate the value of the real option, owned by the company (2). Table 5 provides all the parameters required for this model.

Table 5. Value of the Parameters

Parameter	**Variable**	**Value**
Present value of expected cash flows from Phase 2, million EUR	S	7.38
Value of new investment required in Phase 2, million EUR	X	12.44
Length of time until decision must be made	T	3 years
Continuously compounded risk-free rate (estimated using riskless discount rate r_f (5.3 %) on the basis of the Lithuanian Treasury spot rate of return with maturity equal to the option's time to maturity, see (6)	r	5.2 %
Volatility of expected cash flows (estimated by the company's experts using the Scenario analysis)	σ	46.2 %

The value of the whole strategic investment program is the sum of Phase 1 of NPV and the value of call option – Phase 2.

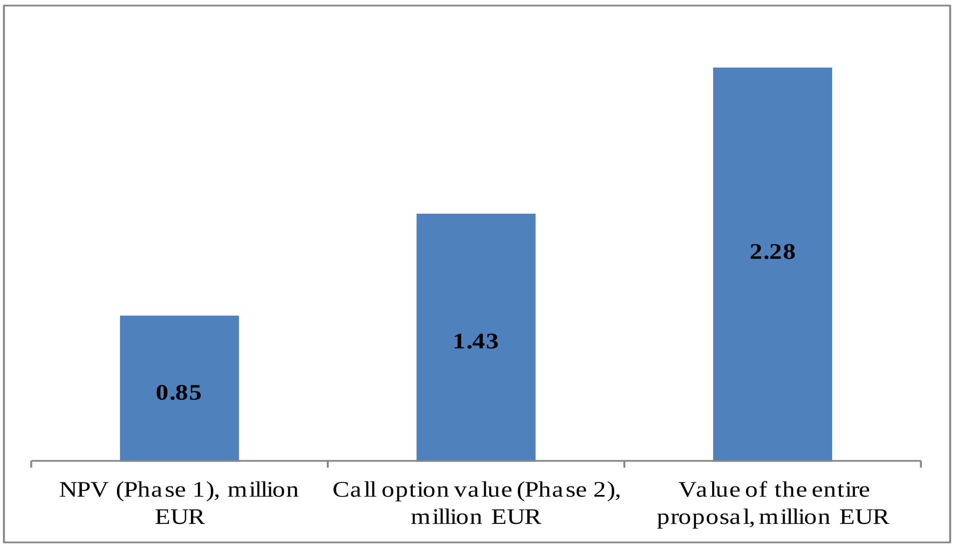

Fig. 2. The value of the strategic investment program (Source: Calculated by the author).

The final estimate of the investment proposal indicates that it is very attractive and should be implemented. Besides, the results obtained have no relation to the original estimate of NPV. Therefore, traditional discounted cash flow analysis, assuming that the company will pursue a preformed plan, despite how the situation unfolds, and ignoring the flexibility to expand (to implement Phase 2) or not to expand, inappropriately measures the value of the two-phased investment program.

CONCLUSION

As a consequence of uncertainty many assumptions of DCF analysis become inadequate for strategic investment project valuation. By adding a dimension of flexibility, ROA allows for a superior connection of strategic intuition and analytical correctness, and the impact of misleading assumptions is eliminated. Therefore, a much clearer view of the strategic investment decision environment can be obtained by supplementing DCF analysis with real options valuation methodology.

The analysis of the Lithuanian company's two-phased strategic solar module production investment program revealed that because of uncertainty inherent in renewable energy sector and necessity to react flexibly to emerging opportunities, real options approach performs better than the conventional DCF analysis. Under NPV, the expected value of investment project is negative (–0.01 million EUR), so the company should not undertake the project. However, the proposed investment and modernization program has a considerable real option value. Phase 1 includes the initial investment and the associated cash inflows. This phase can be valued using NPV approach. Phase 2 pertains to the expansion option, which may or may not be used in year three. The value of the whole strategic investment project (2.28

million EUR) is calculated as the sum of the NPV (Phase 1) of 0.85 million EUR and the value of 1.43 million EUR of call option – Phase 2. The obtained outcome indicates that the investment program is very attractive and should be implemented.

The results of this study suggest that in comparison to DCF analysis, ROA is a more suitable method to apply to the assessment of strategic investment projects related to uncertainty. DCF analysis does not consider managerial flexibility, underestimating the project value. Therefore, if the analysis includes real options in the project, the capital budgeting process is more realistic and improves strategic investment decisions as well as the company's results.

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AUTHOR'S SHORT BIOGRAPHY

Agnė Pivorienė received her Master's degree in the field of Management and Business Administration from Kaunas University of Technology in 2002. She is a PhD candidate in the field of Management and Administration (03S) and a Lecturer at the Department of Finance, School of Economics and Business, Kaunas University of Technology, Lithuania. She has 14 year experience of scientific and educational work.

Her main fields of scientific interest are: company's financial management, financial analysis, investment management, assessment of investment effectiveness.

Address: Gedimino Str. 50, LT-44239, Kaunas, Lithuania.